The Examiner's position on the prior art is set forth in the Action in some detail and will not be repeated here except as necessary to an understanding of Applicants traversal which is now presented.

TRAVERSAL

The Examiner's position appears to be that Shibasaki discloses a method of melting solid metals while dropping them so as to obtain metal balls from the melted metals by cooling/solidifying the melted metals and Eldridge discloses melting wires by using plasma (the heat of plasma).

The Examiner reasons that Shibasaki discloses a technique of supplying wires in a space heater by a heater to cool/spheroidize the wires. In Shibasaki, cut wires are rendered molten/spheroidized by using an atmosphere heated by a heater, i.e., an atmosphere heated by radiant heat. The Examiner admits that Shibasaki does not teach the use of a plasma to heat the cut wires in Shibasaki.

However, the Examiner relies upon Eldridge as teaching that it is conventional to use the heat of plasma to melt wires and that doing so leads to highly accurate results, reasoning it would have been obvious to modify the Shibasaki system to use plasma as the heat source with the benefit of a more controlled heating with more accurate spheres being produced.

THE INVENTION/THE PRIOR ART

A very important aspect of the present invention is that a plasma flame is used to achieve the providing of minute metal balls having high sphericity and a uniform diameter.

The present invention is based in large part upon the use of a plasma flame to generate a high temperature region, e.g., a temperature of greater than 5,000°C, using a high speed gas flow which is quite different from a static atmosphere where there is no gas flow which would be the case where radiant heat from a heater is applied as in Shibasaki. Thus, the present invention is essentially different from Shibasaki in approach. In accordance with the present invention, a dynamic heated space functions as the heat source. One of ordinary skill in the art would not suspect that such a dynamic heat source could be used to obtain minute metal balls having high sphericity and a uniform diameter considering the dynamic nature of the heated space. This may have been based on worries about problems due to the use of a dynamic heated space such as evaporation, metal flying off from the metal being treated or the like due to the extremely high temperature region of the dynamic heated space which is much greater than the melting point of the metal being processed and which involves a high rate of gas flow.

Against such background, Applicants unexpectedly confirmed the following findings. In their research regarding spheroidizing using a plasma flame, only a plasma flame will reach the high temperatures desired. However, since temperature decreases rapidly at a position outside the plasma flame, metal pieces are rendered molten in the high temperature region of the plasma flame to spheroidize the same due to surface tension of the metal itself. The spheridized metal pieces rapidly leave or depart from the plasma flame to be immediately cooled due to the rapid decrease in temperature at positions just outside the plasma flame, the immediate cooling to a temperature lower than the melting point resulting in solidification. Accordingly, due to the rapid departure from the plasma flame and the rapid temperature decrease once outside the

plasma flame, the metal does not undergo substantially any volume change and forms into a metal ball which is substantially a pure sphere. Thus, Applicants have discovered that even if a plasma flame is used and cut wires having a specified shape are used, nonetheless, minute metal balls having a volume basically the same as that of each wire piece and a uniform diameter can be mass produced rapidly and efficiently.

In more detail, specifically in accordance with the present invention, the metal pieces are cut so as to have a length L of wire material with a diameter ϕ less than 2 mm and a ratio of ϕ and L meeting the requirement $0.1 \leqq L / \phi \leqq 3.0$.

Further, the very high temperature atmosphere (plasma flame) is used to heat metal pieces. This permits oxygen forming oxide on any surface of the metal pieces to be removed or dissociated therefrom. Since the oxygen will thus be released into the atmosphere due to the plasma flame sphere formation, metal balls of a uniform diameter and high sphericity can be obtained with an extremely clean surface. This is quite an advantageous effect of the method of the present invention of producing minute metal balls where the same are used in electronic equipment or the like which requires low surface contamination or oxidation so that one achieves lowered electrical resistance of the minute metal balls.

Focusing now on Eldridge, in the production of minute metal balls from cut metal pieces, shape accuracy (formalization) achieved in accordance with any melting-solidification operation is a problem, as it is believed the Examiner will appreciate. This is a consequence of metal pieces dropping into a space of a high temperature atmosphere. In this regard, Eldridge simply shows cutting wire and spheroidizing the tip end of the wire. In more detail, Eldridge does not

relate to a method for producing minute metal balls of high sphericity and of uniform diameter, rather, simply deals with treating the tip end of a wire.

Applicants respectfully submit that the problems involved in Shibasaki and the problems involved in Eldridge are so dissimilar that one of ordinary skill in the art would, in no fashion, consider combining Shibasaki and Eldridge.

What is missing from the prior art, it is respectfully submitted, is any teaching or suggestion that one could cut wire and then introduce wire into a plasma flame and result in a spheroidized product. True, Shibasaki may teach the use of radiant heat which is essentially a "static" system to produce small diameter metal spheres and Eldridge may use a plasma to treat the tip of a wire, but what is lacking is any suggestion in the prior art that a dynamic plasma flame could be used, a rather "violent" system, to take small pieces of metal wire and quickly, and rapidly not only form the same into spheres which successfully solidify to spherical form upon departure from the plasma flame but also are simultaneously cleaned so as to remove oxidation products.

With respect to claim 3, while the Examiner considers the "tolerances" as claimed (presumably the average volume and CV value) to involve mere routine optimization, what is lacking to support a "routine and obvious choice" position is any suggestion in the prior art that the parameters would have any effect on the results obtained. Barring some teaching in the prior art that the parameters of claim 3 are result-effective parameters, Applicants respectfully submit that there would be no reason for one of ordinary skill in the art to even consider changing average volume and the CV value to optimize the same.

Withdrawal of the rejection and allowance is requested.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

Peter D. Olexy
Registration No. 24,513

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON OFFICE
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